Indicator: Urbanization and Population Change (256)

Population change is a major driver affecting numerous environmental outcomes. The total number of people and their distribution on the landscape can affect the condition of the environment in many ways; for example, increasing population often means increased urbanization, including conversion of forest, farm, and other lands for housing, transportation, and commercial purposes. In recent years many communities in the U.S. have seen an increase in developed land area that outpaces population growth. This pattern is of concern for numerous health and environmental reasons. For example, studies indicate that when land consumption rates exceed the rate of population growth, per capita air pollutant emissions from driving tend to be higher (Frank, 2004). In addition, urbanization and population growth tend to increase the amount of impervious surfaces and the quantity and types of products that humans produce, use, and discard, thereby affecting waste generation and management, water quality, and chemical production and use.

The information presented in this indicator is based on population data collected and analyzed on a decadal basis by the U.S. Census Bureau, and data collected by the USDA Natural Resources Conservation Service National Resources Inventory (NRI) to track "developed" land (residential, commercial, industrial, and transportation uses). Between 1977 and 1997 the NRI developed estimates every five years on non-federal lands in the contiguous U.S. Since 2001 NRI has developed annual estimates, based on a smaller sample size.

What the Data Show

Figure 256.1 shows absolute U.S. population growth from 1790 to 2000, including the amount of urban population change. During the past half-century (1950-2003), the population of the United States nearly doubled going from 150.7 to 290.8 million people (U.S. Census, December 2004).

In Figure 256.2, trends in urbanization and population are compared by displaying the amount of developed land relative to the amount of population change. Between 1982 and 2002, the amount of developed land in the U.S. grew by more than 34 million acres, representing a cumulative increase of approximately 47 percent (U.S.D A, Natural Resources Conservation Service, April 2004). The Census Bureau estimates that during the same period, the population of the U.S. (not including Alaska and the District of Columbia) grew by slightly more than 56 million people, or just over 24 percent (U.S. Census Bureau, December, 2004). Thus, the amount of developed land increased at nearly twice the rate of the population.

Performing the same comparison by EPA Region highlights substantial variations in population and development trends in different parts of the U.S.. Figure 256.3 shows Regional changes in population growth and developed land between 1982 and 1997. During this time, Region 4 experienced a 27 percent increase in population (10.8 million people) and a 55 percent increase in the amount of developed land. This increase in developed land represents over 8 million acres and nearly 33 percent of the total US increase in acreage developed during that time (U.S.D.A, December 2000). In general among the Western Regions (8, 9, and 10), the amount of land developed closely matched population growth. In fact, the developed acres per capita decreased in the much of the west (Regions 8 and 9). In the Northeast, in contrast, the rate of increase in developed land was nearly four times that of population (Regions 1, 2, and 3). Regions in the Midwest and South (Regions 4-7) fell in-between with percent increase in developed land ranging from 1.6 to 3.2 times the rate of population change.

Figure 256.4 shows the change in population density by EPA Region and for the U.S. as a whole from 1950 to 2003. In 2003, Region 2 had the highest density at more than 509 people per square mile. For the last fifty years, Region 2 has consistently maintained more than twice the population density of all other

Regions. The least dense Region in 2003 was Region 10, with an average of slightly more than 14 people per square mile (including Alaska). The national average in 2003 was 82.2 people per square mile. The largest population increase in both absolute and percent change between 1950 and 2003 occurred in Region 9 where population increased by nearly 33 million people, a 272% change. (U.S. Census Bureau, November 2002 and July 2004). In that same time frame, 32 million people were added to Region 4 for a 133% increase. (U.S. Census Bureau, November 2002 and July 2004).

Indicator Limitations

Census data:

- Inter-censal figures are estimates based on sampling, and thus differ from the decennial census data in methodology and accuracy.
- There are sampling and non-sampling errors for all Census data as a result of errors that occur during the data collection and processing phases of the census.
- Puerto Rico and Virgin Island data are not available for all years, and thus have not been included, affecting the accuracy of the statistics for Region 2.
- The criteria for estimating urban population have changed over time as defined by the Census Bureau.

Natural Resources Inventory (NRI) data:

- NRI sampling procedures changed in 2000 to an annual survey of fewer sample sites than had previously been sampled (starting in 1977, NRI sampled 800,000 points every five years). Fewer sample points means increased variance and uncertainty and an inability to develop estimates on a state or regional basis. (These estimates will be available in the future as more points are sampled annually.)
- NRI collects some data across the entire nation, including Puerto Rico and the Virgin Islands. Land use statistics, however, are not reported on federal lands or for Alaska and the District of Columbia.

Data Sources

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http://www.census.gov/popest/states/tables/NST-EST2003-01.xls

U.S. Census 2000, Summary File 4, Technical Documentation. Washington, DC: U.S. Census Bureau, June 2004, SF4/09 (RV). http://www.census.gov/prod/cen2000/doc/sf4.pdf.

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U.S. Census Bureau, *Demographic Trends in the 20th Century: Census 2000 Special Reports.* Washington DC: U.S. Census Bureau, November 2002. http://www.census.gov/prod/2002pubs/censr-4.pdf

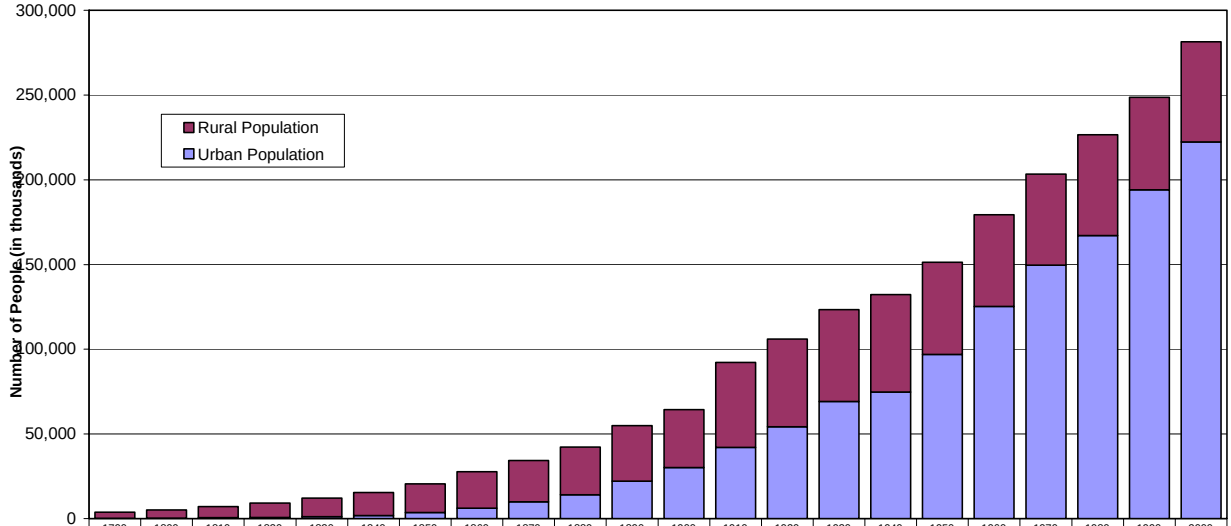
U. S. Census Bureau, *Statistical Abstract of the United States 2004-2005: The National Data Book.* Washington DC: U.S. Census Bureau, December, 2004. http://www.census.gov/statab/www/.

U. S. Department of Agriculture, *2002 Annual NRI: Land Use*. Washington DC: U.S. Department of Agriculture, Natural Resources Conservation Service, April 2004. http://www.nrcs.usda.gov/technical/land/nri02/landuse.pdf

U. S. Department of Agriculture, *1997 Five-Year NRI: Acreage and Percentage of Non-Federal Land Developed* . Washington DC: U.S. Department of Agriculture, Natural Resources Conservation Service, December 2000. http://www.nrcs.usda.gov/technical/land/meta/t5846.html

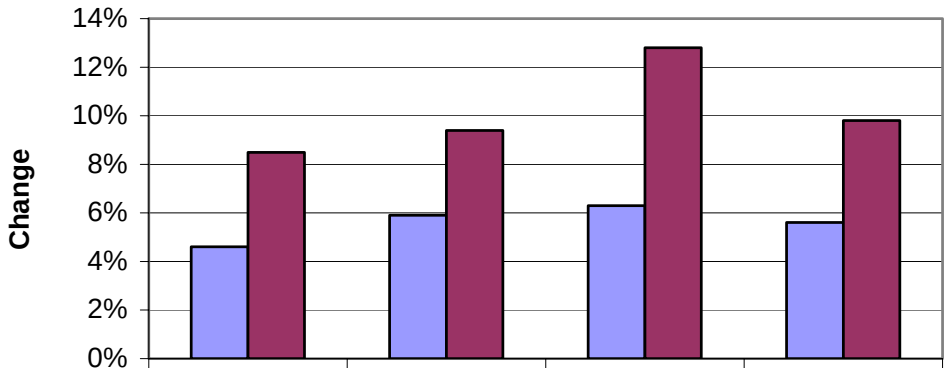
Graphics

Figure 256.1: Population Growth and Urbanization, 1790-2000



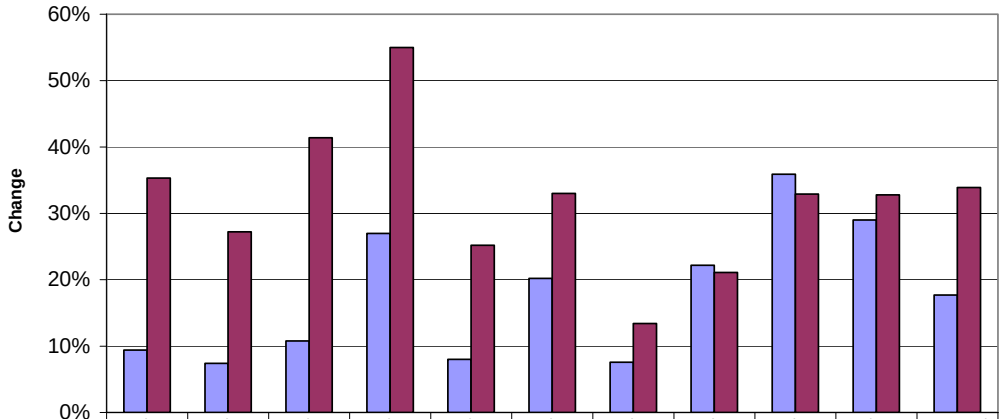
	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Rural Population	3606.843	4783.024	6546.626	8511.206	11015.65	13488.86	16975.36	21540.96	24428.64	28082.94	32764.93	34148.17	50164.5	51768.26	54253.28	57459.23	54478.98	54054.43	53655.41	59491.21	54621	59061
Urban Population	201.655	322.371	525.459	693.255	1127.247	1845.055	3574.496	6216.518	9902.361	14129.74	22106.27	30214.83	42064	54253.28	69160.6	74705.34	96846.82	125268.8	149646.6	167051	194097	222361
total	3929.214	5308.483	7239.881	9638.453	12860.7	17063.35	23191.88	31443.32	38558.37	50189.21	62979.77	76212.17	92228.5	106021.5	123202.6	132164.6	151325.8	179323.2	203302	226542.2	248718	281422

Figure 256.2: Percent Change in Population and Developed Land in the U.S., 1982-2002

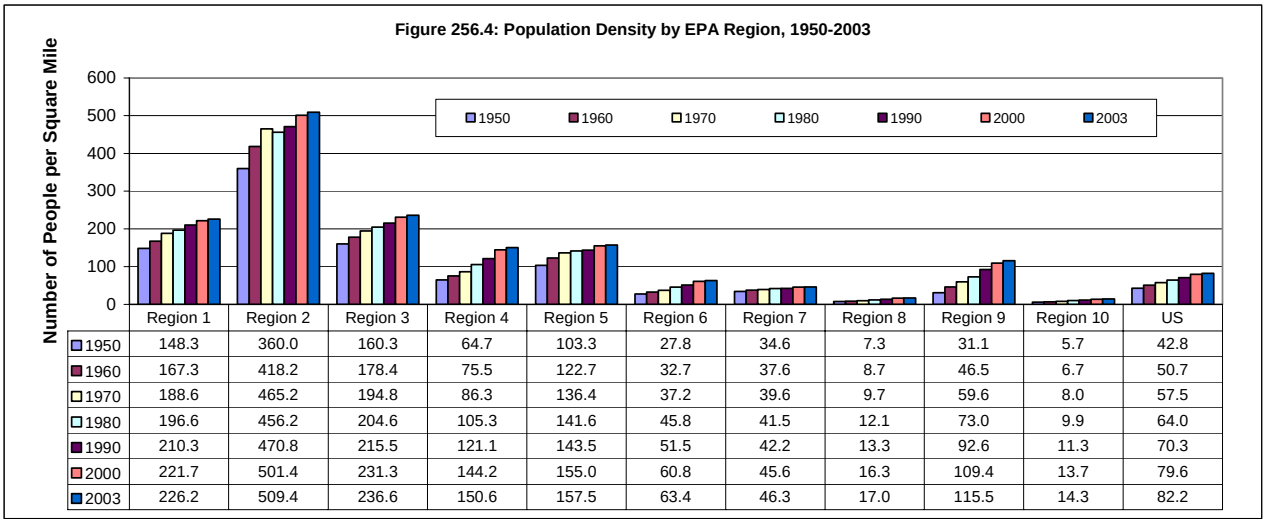


	1982-87	1987-92	1992-97	1997-2002
Change in Population	4.6%	5.9%	6.3%	5.6%
Change in Developed Land	8.5%	9.4%	12.8%	9.8%

Figure 256.3: Percent Change in Population and Developed Land by EPA Region, 1982 to 1997



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	US Total
Change in Population	9.4%	7.4%	10.8%	27.0%	8.0%	20.2%	7.6%	22.2%	35.9%	29.0%	17.7%
Change in Developed Land	35.3%	27.2%	41.4%	55.0%	25.2%	33.0%	13.4%	21.1%	32.9%	32.8%	33.9%



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	US
1950	148.3	360.0	160.3	64.7	103.3	27.8	34.6	7.3	31.1	5.7	42.8
1960	167.3	418.2	178.4	75.5	122.7	32.7	37.6	8.7	46.5	6.7	50.7
1970	188.6	465.2	194.8	86.3	136.4	37.2	39.6	9.7	59.6	8.0	57.5
1980	196.6	456.2	204.6	105.3	141.6	45.8	41.5	12.1	73.0	9.9	64.0
1990	210.3	470.8	215.5	121.1	143.5	51.5	42.2	13.3	92.6	11.3	70.3
2000	221.7	501.4	231.3	144.2	155.0	60.8	45.6	16.3	109.4	13.7	79.6
2003	226.2	509.4	236.6	150.6	157.5	63.4	46.3	17.0	115.5	14.3	82.2

R.O.E. Indicator QA/QC

Data Set Name: URBANIZATION AND POPULATION CHANGE
Indicator Number: 326 (89170)
Data Set Source: NRI (see # 325 for metadata) and US Census (see # 256)
Data Collection Date: 1982, 1987, 1992, 1997 (2002)
Data Collection Frequency: NRI - annually-5 years
Data Set Description: Comparison of population change and change in developed lands
Primary ROE Question: What are the trends in land use and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, to the extent that Census data are viewed as “physical measurements,” the Census Bureau statistical sampling is viewed as valid. Similarly, the NRI data collected as an inventory are accepted as valid for the estimation of various non-federal land uses. Yes. The Natural Resources Inventory (NRI) generates estimates, in million of acres, of the amount of nonfederal land in the United States. Nonfederal land includes land that is

either privately owned, or managed by Native American tribes, in a trust, or by a state or local government. In 2002, this estimate was approximately 1.49 billion acres. Comparing the data from 2002 to previous data (NRI surveys were conducted starting in 1977 and every five years thereafter) allows for comparisons that establish trends in non-federal land use in the United States. With the advent of the annual NRI, yearly trends and changes will be able to be generated in the future. Uncertainty measurements for the 2002 NRI have yet to be calculated, as the national estimates were based on a smaller sampling size than previous NRIs and state by state estimates have not been concluded yet. In 1997, the NRI estimated that there were 98.3 million acres of developed land, with an estimated margin error of 884,000 acres, or less than 1% at the 95% confidence interval. Further detail on the current study methodology are available on the NRI website: http://www.nrcs.usda.gov/technical/land/nri02/

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Decennial census data are based on a comprehensive survey of the entire resident U.S. population. Census data are derived from information provided by the Census questionnaire. An analysis of the data collection procedures of Census 2000 can be found at http://www.census.gov/pred/www/rpts/TR13.pdf. Annual July population estimates are generated by a formula that uses 2000 census data to calculate change. This formula uses births to U.S. resident women, based on data supplied by the National Center for Health Statistics; registered deaths to U.S. residents, also estimated from data from the NCHS; net international migration, calculated from Census 2000 Supplementary Surveys and the Demographic Analysis and Population Estimates (DAPE) project; and net movement of U.S. Armed Forces, based on overseas strength statistics supplied by the five branches of the Armed Forces in the Departments of Defense (Army, Navy, Marines, and Air Force) and Transportation (Coast Guard). The US Census Bureau has adopted and follows Section 515 information quality guidelines as mandated by the Office of Management and Budget (OMB) to ensure the highest level of data accuracy possible. http://www.census.gov/qdocs/www/quality_guidelines.htm The sampling and monitoring plan for NRI is based on sound scientific principles. Approximately 800,000 total sample sites in every state in the country are included, and cross-indexed data gathering, instructions, and survey instruments were developed to foster consistent data gathering standards, practices, and procedures. USDA is currently transitioning to a fully implemented annual NRI, with reliability levels approaching those of the 1997 NRI. State and regional estimates have yet to be released, and national estimates were based on much smaller sampling size. Until reliability levels approach those of previous surveys, differences in methodology and reliability must be accounted for. Differences in methodology between 97/02 can be viewed at http://www.nrcs.usda.gov/technical/NRI/1997/data_gathering.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Decennial census data are the primary and authoritative source for national, regional, state, and local population data in the United States. As such, the data are

reliable for establishing an indicator that seeks to report the status of population growth, and establish trends in population change. When coupled with measurements of land area, these data provide a reliable indicator of population density change.Yes. The NRI has the ability to track changes over a finite time frame in the amount of land used for specific uses.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Decennial census population data, while not a sample, are collected every ten years, and thus allow a view of both status and trends related to population growth and change. Annual population estimates are based on a formula that utilizes reliable data sources. Thus, analyzing both status and trends based on yearly estimates can be done with a high level of confidence.The NRI uses a stratified two-stage unequal probability area sample to ensure that sample sites are located in all counties and parishes of the 50 states and in Puerto Rico, the Virgin Islands, the District of Columbia, and selected portions of the Pacific Basin. The primary sample unit, or PSU, is the area or segment of land, from which one or more points are selected. In 1997, data was gathered from approximately 800,000 points in 300,000 PSUs. As mentioned earlier, the methodology has been changed in an attempt to expedite the generation of national estimates. 2002 NRI data was collected from 150,000 sampling sites between July 2002 and March 2003. http://www.nrcs.usda.gov/technical/land/nri02/. Land use data are not reported on federal lands or for Alaska and the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable for Census or NRI data.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Data collection and analytical procedures can be found throughout the Census 2000 website, including http://www.census.gov/prod/cen2000/doc/sf1.pdf and http://www.census.gov/pred/www/rpts/TR13.pdf. Census data sets are known to contain errors, outlined in the Census Bureau's statement on statistical quality, available on its website. http://www.census.gov/main/www/policies.html#quality Statistical reliability and methodology of the 1997 NRI is available at (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html) while changes in methodology and reliability for the annual NRIs can be viewed at http://www.nrcs.usda.gov/technical/land/nri02/. The most notable difference that is documented is the change in the number of sampling sites that are included, a decrease of nearly 75%. The precision of NRI estimates depends upon the number of samples within

the region of interest, the distribution of the resource characteristics across the region, the sampling procedure, and the statistical estimation techniques.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Metadata regarding quality assurance and quality control issues, as well as data dictionaries and definitions can be found throughout the Census website. Confidentiality is not an issue for the level of resolution required in the ROE. Metadata and definitions are available for specific geographic areas, including metropolitan areas. (http://www.census.gov/geo/www/cob/ma_metadata.html)Complete NRI data files are not available on the website, but can be obtained on CD-ROM (for the 1982-1997 NRIs) from the USDA (see http://www.nrcs.usda.gov/technical/NRI/1997/obtain_data.html). The processing fee is $50. What data are available can be accessed via: http://www.nrcs.usda.gov/technical/NRI/. There are metadata available.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, the study design is clear. The methodology, including the operations and questionnaires used by Census takers, can be found on the FAQ section of the Census website (http://www.census.gov/dmd/www/refroom.html).The survey design and description of the NRI is clear and complete, including the difference in data sources and methodology that have occurred since the shift to the annual NRI. The statistical design, data gathering, and estimation procedures are all available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/).

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

As mentioned earlier, the Census Bureau has adopted Section 515 Information Quality guidelines published on the website. Other procedures for quality assurance and quality control are contained in technical documentation available on the website.The appendices of the 1997 NRI, readily available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/), discuss issues related to reliability, as well as protocols for quality assurance and control.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, appropriate methods are used. The decadal census is a comprehensive sample. Inter-censal analyses were described previously. The 1997 NRI was based on 800,000 sample sites on non-federal lands, in every state in the country, in an attempt to generate an accurate picture of land use/land cover at a state and national level. Annual NRIs compiled since 2000 have been based on a subset of approximately 150,000 to 200,000

sample sites, but starting in 2005, it is anticipated that the annual NRI will approach the reliability of the 1982 through 1997 Five-Year NRIs. Generalization is still possible, but the margin of error in national estimates has gone up, and margins of error for state estimates are not yet available. Generalization to federal lands is not possible.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. As noted in the Census Bureau's statement on statistical quality (referenced above), "all survey and census results contain measurement error and may contain sampling error", with "available information about these potential errors& provided or referenced in data products as they are presented".Yes. For the 1997 and prior data, uncertainty measurements are included in the appendices to the reports. The margin of error for the 1997 annual NRI was approximately twice the estimated standard error, and could be used to construct a 95 percent confidence interval for most states. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not in any major way. Census data are the most accurate, exhaustive, and time-consuming method for collecting information that aims to determine the status of, and establish trends in, population and population change over time. Potentially. Through 1997, NRI estimates are generated from approximately 800,000 sample sites throughout the country. The 2002 annual NRI is based on 150,000 sample sites, as a smaller sample was needed to allow for more timely reporting of results. Reliability levels for the annual NRIs (national and state level data) are not expected to approach those of the 1997 Five-Year NRI until 2005. State and regional level reports are not currently available for 2002. Again, land use data for federal lands are not available. Land use data are not reported for Alaska and the District of Columbia. http://www.nrcs.usda.gov/technical/land/nri02/)

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Census data are the most comprehensive data set on population available, and an excellent source for producing an indicator on population and population change over time. While measurement and sampling errors do exist, especially when calculating population estimates or projections, gaps or limitations in the data set should not mislead users on fundamental trends in the indicator over space or time.